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16. ABSTRACT

Reducing the generation of industrial and other wastes can be achieved in many ways. Process chemistry can be changed, potential waste streams can be recycled within a manufacturing process or back into the process; process technology and/or equipment can be modified to produce products more efficiently, resulting in less waste; changes in raw materials (feedstocks) can lead to fewer waste streams or less-hazardous waste streams; finally changes in the end products from manufacturing operations can, in some instances, be made so as to affect the types and quantities of wastes emitted. EPA's waste minimization research, development and demonstration programs described in this paper address several of these issues.

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We have started into a turning point in the history of the earth. The potential consequences of our actions, due to their sheer numbers and magnitude, and due to the accelerating nature of these activities, coming as a result of such things as population growth, increasing use of energy and products per person per year and as a result of the less developed countries finding ways to follow our lead, can alter the environment in irreversible ways that can make it unhealthy for our children and even ourselves.

The Environmental Protection Agency (EPA) has been working to improve the way we handle and dispose of wastes that minimizes the danger to our health and the environment. However, in the light of the results that are achievable by this approach and with the knowledge that the types and volumes of waste being generated are on an accelerating rise, it has become clear that the idea of generating the wastes first and dealing with them thereafter is not only very expensive in the overall perspective, but also potentially risky to the future well being of the planet.

The new approach being taken by the Agency is to avoid or minimize these problems by the widespread application of pollution prevention techniques that keep from generating the waste in the first place. At the start of this program the Agency focus was on the minimization of waste from the industrial and hazardous waste generators. It has quickly become obvious that this approach requires focus on all waste being generated, and not only on the industrial process but in a much broader sense, involving the evaluation of consequences starting from the choice of raw materials used to the pollution problems created by both the use of the product/service and the ultimate disposal of the product waste.

The Pollution Prevention Research Branch (formerly the Waste Minimization Branch) within the Risk Reduction Engineering Laboratory is the primary organization charged with the responsibility for the technical aspects of the pollution prevention research program. This paper focuses on the research efforts of the Pollution Prevention Research Branch, specifically highlighting the work being done in the Waste Reduction Innovative Technology Evaluation (WRITE) Program. Other organizations involved in this effort are the Office of Solid Waste (OSW) and the Pollution Prevention Office (PPO)

within the Office of Program Planning and Evaluation (OPPE). The functions of these major offices and major pollution prevention programs are also summarized.

BACKGROUND

Within the past year, the EPA has taken several actions to encourage a national program of pollution prevention. It has created an organization to serve as the focal point for pollution prevention activities, issued a policy statement defining it's position on pollution prevention and started a set of programs to begin or facilitate the application of pollution prevention techniques and procedures across the Nation. As it is used today, "pollution prevention" replaces the term "waste minimization" which was generally applied to the reduction of hazardous wastes, and defined in the 1984 Hazardous and Solid Waste Amendments (HSWA) to the Resource Conservation and Recovery Act (RCRA) of 1976 (1). Through this terminology, EPA is emphasizing that it's pollution prevention policy has applicability beyond the RCRA hazardous waste context.

EPA's pollution prevention program is based on several elements including: (1) promoting waste reduction by transferring technical information to industry and State and local government technical assistance officers; (2) encouraging the adoption of waste reduction by identifying, evaluating, and demonstrating appropriate technologies and by promoting the use of waste audits or assessments; (3) keeping Congress advised on national progress of waste reduction techniques and practices; (4) fostering development of State and local government pollution prevention programs; and, (5) developing outreach and communication programs with the goal of raising awareness of the

benefits of waste reduction practices within government, industry, and the public.

In January 1989, the Agency issued a Pollution Prevention Policy Statement (2). This policy encourages organizations, facilities and individuals within the United States to fully utilize source reduction and recycling practices and procedures to reduce risk to public health, safety and the environment. Source reduction is emphasized as the preferred approach since it eliminates or significantly reduces the quantity of pollutants generated. As a second choice, recycling reduces the amount of waste requiring treatment or disposal. Many waste reduction efforts have proven to be economical, in the long run, as well as beneficial to the environment, thus producing a win-win situation.

Source reduction has been defined as the reduction or elimination of waste at the source, usually within a process. Source reduction measures include process modifications, feedstock substitutions, improvements in feedstock purity, housekeeping and management procedural changes, increases in the efficiency of equipment, and recycling within a process. Likewise, recycling has been defined as the use or reuse of a waste material as an effective substitute for a commercial product or as an ingredient or feedstock in an industrial process. It includes the reclamation of useful constituent fractions within a waste material or the removal of contaminants from a waste to allow it to be reused (3).

MAJOR PROGRAMS

Three offices within the EPA house the evolving Pollution Prevention Program. These are the Office Of Solid Waste (OSW), the newly created

Pollution Prevention Office (PPO) within the Office of Program Planning and Evaluation (OPPE), and the Office of Research and Development (ORD).

The OSW participated in the early stages of waste minimization by developing programs for hazardous industrial waste minimization under RCRA. This has provided a base for the present, expanded Pollution Prevention Program. During 1989, it is formulating a national RCRA strategy that will identify action items for the promotion of source reduction and recycling activities associated with industrial hazardous waste, municipal waste, industrial nonhazardous waste, special wastes such as mining, gas and oil production and power generation. The strategy documents for minimizing these wastes are expected to be completed during the summer of 1989.

The PPO has been formed to implement the Agency's pollution prevention agenda. Several of the main activities include publication of the Agency's Policy Statement on Pollution Prevention, the establishment of a Source Reduction and Recycling Technical Assistance Grant Program for the states, establishing a National Pollution Prevention Information Clearinghouse in conjunction with the Pollution Prevention Research Branch within ORD and publishing a Pollution Prevention Newsletter. Most recently it has been also charged with administrating a 2% set-aside initiative program consisting of competitive pollution prevention research initiatives within the Agency that are to be funded from 2% of the Agency's budget set aside for sponsoring "winning" pollution prevention research ideas.

The ORD has been charged with providing the technical research support via the Risk Reduction Research Laboratory and the Pollution Prevention Research Branch specifically. The main programs within the Pollution Prevention Research Branch are Waste Reduction Evaluations at Federal Sites

(WREAFS), the Pollution Prevention Information Clearinghouse (PPIC), the Waste Reduction Institute for Scientists and Engineers (WRISE), the Waste Reduction Assessment Program (WRAP), and the Waste Reduction Innovative Technology Evaluation (WRITE).

WREAFS

This research program consists of a series of demonstration and evaluation projects for waste reduction conducted cooperatively by EPA and other Federal agencies such as the Department of Defense (DOD) and the Department of Energy (DOE). The WREAFS Program focuses on waste minimization research opportunities and technical information at Federal sites.

Many Federal activities have established waste reduction plans and programs in the past few years. For example, an overall goal within DOD is to reduce hazardous waste generation a total of 50 percent by 1992 compared with 1985 levels. Several operation and process opportunities for waste reduction exist at Federal sites that will reduce hazardous waste and result in cost avoidance or cost reduction as well as productivity, environmental, and human health benefits. Waste minimization opportunities can be applied throughout the Federal community in fabrication, production, and/or maintenance processes, depending on the waste generating function. Industrial activities that support Federal activities through in-house or contracted efforts are generally the same activities as those within the private sector. The application may vary, depending on the final product. However, waste reduction techniques can be successfully employed in both the public and private sectors.

The objectives of the WREAFS Program include the following:

* Conduct waste minimization workshops;
* Perform waste minimization opportunity assessments;
* Develop technical information transfer opportunity assessments;
* Provide EPA developed research information to Federal facilities;
* Demonstrate waste minimization techniques or technologies at Federal facilities;
* Promote and enhance waste minimization benefits within the Federal community.

As a part of recent meetings with representatives from DOD, the VA and EPA, candidate sites were solicited to conduct waste minimization opportunity assessments. Six assessments are planned in fiscal year 1989 with each branch of the military offering one candidate site along with one each from the VA. The WREAFS Program anticipates active participation from within the Federal community with EPA providing the catalyst for technology demonstration and technology transfer.

PPIC

Through the Pollution Prevention Information Clearinghouse, a public domain, computerized information network for the exchange of pollution prevention information among states, local governments, generators, industry organizations, and the Federal Government is being established. This activity is being jointly undertaken by ORD and the PPO. Some of the issues that have been addressed under PPIC include establishment of a commonly accepted

accession/indexing technique for clearinghouse holdings, incorporation of a hot line telephone number for pollution prevention information updates, assurance of hard copy materials when requested, and incorporation of an electronic information exchange capability. Services anticipated through PPIC include: indexed bibliographies and abstracts of pollution prevention reports and publications, case studies of demonstrations and evaluations of waste reduction technologies, a calendar of events including conferences, seminars, Federal and state activities in pollution prevention, an electronic bulletin board for communication and message transmittal among users, and a list of state, Federal, industry, trade organization and other recognized contacts knowledgeable in various aspects of pollution prevention activities.

WRISE

The Waste Reduction Institute for Scientists and Engineers is a joint university/EPA sponsored institute comprised of individuals knowledgeable in the principles and practices of waste reduction. Some of the Institute members are retired from distinguished careers in industry. The overall purpose of the group is to counsel EPA with respect to its pollution prevention activities and to serve as liaisons to private industry generators that the Agency wishes to encourage to adopt and demonstrate waste reduction techniques. Review and comment on individual project documents and participation as lecturers in pollution prevention seminars will be undertaken by the Institute personnel.

WRAP

The Waste Reduction Assessments Program (WRAP) encourages the industrial community's use of waste minimization assessments. The WRAP Program is designed to assist users in applying waste minimization assessments as a tool for identifying options for reducing waste generation. These assessments may be conducted internally by in-house teams or through external means, such as consultants, with in-house assistance. Preliminary assessments will be followed by long-term studies to verify the lasting effectiveness of waste minimization applications.

Initial efforts in the Program will demonstrate and evaluate EPA's Manual for Waste Minimization Opportunity Assessments (4) across a broad scope of industrial settings. The development of standard procedures applicable over a broad range of business sizes and types will provide a uniform basis for those in decision-making roles to implement, postpone, or reject identified options. Experience with the assessment protocol will demonstrate the effectiveness of translating incentives and disincentives for waste minimization into quantifiable factors that can be ranked objectively. Where appropriate, evaluations will conclude with revisions to the manual. Suggested amendments will be transferred to state and regional waste minimization programs. Expanded efforts within the Program include tailoring the EPA manual to reflect the needs of individual industries.

The remainder of this paper will focus on the projects and activities of the WRITE Program.

WRITE PROGRAM

The WRITE Program is aimed at identifying, demonstrating or enhancing the efficiency of technologies via research and development projects that hold promise in the reduction of waste.

Reducing the generation of pollutants can be achieved in many ways. Enlightened product design can include smart selection of feedstock material type and purity. Process chemistry can be changed; potential waste streams can be recycled within a manufacturing process or back into the process; process technology and/or equipment can be modified to produce products more efficiently and with less waste generated; plant operations can be changed or controlled to produce fewer and smaller waste streams or less waste in general; and product design can also prevent or minimize pollution generated due to product use, consumption and product life. Enlightened use of products by the consumer can impact significantly the amount of pollution generated. Finally, the recyclability and disposal requirements can be greatly enhanced by both product design and consumer disposal practice. Obviously, this scope involves technological, educational and sociological input. Only the technical and immediate technology transfer elements are included within this program. Incorporated within the WRITE Program are three basic approaches. Cooperative efforts with State and local governments, aimed at waste generated by small and medium size industries and fairly "mature" innovative technologies with the potential for quick application, forms the first approach. The second is aimed at the large industries, while the third covers promising new and unproven technologies and also attempts to provide support in the anticipatory research arena. All programs are designed to address waste issues on a multi-media basis.

WRITE Pilot Program With State and Local Governments

The WRITE Pilot Program With State and local governments addresses immediate information transfer needs between government and industry. Through the joint efforts of EPA and various State and local governments technical and economic evaluations of source reduction and recycling technologies are being conducted of manufacturing and processing operations. This approach was selected because State and local governments would be more familiar with local waste problems, industrial practices and regional manufacturing and economic interests that can affect the potential success and widespread applicability of proposed pollution prevention technologies. States currently participating in this program include California, Connecticut, Illinois, Minnesota, New Jersey, and Washington. Small and medium companies were targeted because of the economies of scale would tend to preclude these entities from affording sophisticated pollution prevention research activities and staffing for the pursuit of waste reduction projects (unlike the large concerns that employ full environmental departments).

In selecting technologies to be evaluated, attention is directed toward methodologies with the potential for reducing the quantity and/or toxicity of waste produced at the source of generation, or the potential to achieve practicable on-site reuse or recycling of waste materials. Strong consideration is given to the applicability of a technique on an industry-wide basis and across industries. Industries of primary interest include chemical, fabricated metals, electronic, printing and publishing, lumber, petroleum, transportation, food, and textile (5). The objectives of the Program include the following:

- Establish reliable performance and cost information on pollution prevention techniques by conducting evaluations or demonstrations of the more promising innovative technologies;
- Accomplish an early introduction of waste reduction techniques into broad commercial practice;
- Encourage active participation of small and medium companies in evaluating and adopting pollution prevention concepts by providing support to these companies through State and local government agencies;
- Encourage the transfer of knowledge and technology concerning pollution prevention practices between large, medium, and small industries.

Under this Program, $100,000 per year is provided by EPA to each participating state/local government. The state/local government also contributes additional matching funds ranging from 25% to 100% of the cost of the research. An average of five waste reduction technologies are to be evaluated by EPA and each state/local government during a 3-year period. Waste reduction technologies evaluated under this program are based on several selection criteria. These include: (1) type of waste reduction technology, (2) status of development, (3) unique nature of the technology, (4) application, (5) source reduction performance capability, (6) extent of process modification, (7) cost effectiveness of the technology, (8) process safety and health considerations, (9) cost to EPA and the state/local government, and (10) legal/contractual issues.

The technical and economic evaluations conducted for each technology include an in-depth study of the process, a literature review of comparable processes, material and energy balance computations, a field demonstration, and determination of cost estimation parameters including itemization of

capital and operational costs, calculation of the payback period and return on investment. A summary of the types of information collected during a technical and economic evaluation of a waste minimization technology under this program is shown in Table I. The example concerns the modification of a cold solvent cleaning process. In the cold cleaning of ball bearings with solvents, using a two-step countercurrent cleaning sequence can increase the cleaning efficiency. It can also substantially reduce the solvent requirement and, hence, the waste generation. This process does not involve substantial equipment modification. Material balance calculations indicate a waste reduction of 50 percent and a 33 percent reduction in fresh solvent requirements (6).

An example of a state, technology evaluation program is the project starting with the State of California. The California/EPA WRITE Program is being conducted in cooperation with the Alternative Technology Section of the Toxic Substances Control Division within the Department of Health Services (DHS) of the State of California. A Solicitation of Interest (SOI) announcing the State of California's Hazardous Waste Reduction Award and the California/EPA WRITE Program was distributed to over 2000 industries, trade associations and other organizations within the state. Information obtained from this SOI has been used to identify a candidate pool of interested companies that have developed innovative waste reduction technologies. Those technologies determined to be the most successful and having the broadest application for waste reduction throughout the state will be evaluated under the California/EPA WRITE Program throughout the next three years.

Since initiation of the California/EPA WRITE Program earlier this year, several waste reduction technologies have been identified. A brief

description of some of the technologies being considered for further evaluation is presented below.

Printed Circuit Board Plating Operation. This new automated copper plating system which incorporates an on-demand spray rinse system replaced a traditional rinse-tank electroplating operation in the printed circuit (PC) board line. The new system is fully automated and has resulted in reductions of process water flows from 45 to 15 gpm. A computer and central process controller assist in the control of automatic chemistry replenishment, rectifier and flight bar control, immersion time, and sequencing of components. As a result of this system, the speed of the line has been increased from 5 hours per batch to 2.5 hours from start to finish. It is anticipated by General Dynamics Pomona Division (GDPD) that the new plating line, which has an installed cost of $4.1 million, will result in a capacity increase of over 50 percent, providing the facility with the potential of producing all PC boards in-house.

Proportional Paint Mixing. This system replaced a hand-mixing batch operation by feeding preselected quantities of individual paint components directly to the paint spray nozzle. Thus, wastes from excess paint usage and from excess batch sizes made unusable by hardening were eliminated. Capital cost of the system was $36,000.

Freon Recovery Stills. A total of eight Freon stills were installed over a 3-year period at a cost of approximately $600,000 to recover Freon from degreasing operations. Along with two additional paint shop solvent stills, GDPD was able to reduce solvent purchases by 35 percent or from 621,000 to 421,000 lb/yr.

Bead-Blast Paint Stripper. A bead-blast paint stripper was installed at a cost of $18,000 to replace a methylene chloride stripping system. The bead-blast stripper utilizes reusable plastic beads in a mechanical stripping operation similar to sand blasting. This operation eliminated 10,000 lb/yr of methylene chloride that was sent off-site for disposal. The paint chips are now incinerated off-site.

WRITE Program With Industry

The WRITE Program With Industry is designed to evaluate innovative pollution prevention technologies currently practiced or under development by large industries. The objectives are to transfer pollution prevention technology to the medium and smaller companies.

Current efforts under this Program include a study to quantify waste reduction measures by industry sector, and to develop more effective tools for measuring and comparing waste reduction across industries as well as within an industry. A second study concerns the evaluation of waste reduction technologies in the transportation industry such as the use of Freon recapture devices in automobile garages. A study is also underway to evaluate the chemical substitution of water-based cleaners for organic solvents in a small parts cleaning operation. As part of the process, the company applies porous coats to joint replacement implants. The implants, made either from cobalt-molybdenum alloy or titanium alloy, are grit-blasted with silicon carbide and then cleaned in order to achieve a good bond between the porous coat and the implant. The cleaners used previously by the company were TCE and methanol; another company with similar operations uses acetone. Preliminary calculations showed savings on both raw materials and disposal costs when a water-based cleaner was substituted for the organic cleaners. A bench-scale

study was conducted with an aqueous cleaner to determine if product quality could be maintained. Bond strength measurements of the coatings produced on the implants cleaned with the aqueous cleaner were as good as, or better than coatings on implants cleaned with organic solvents. Further evaluations are still being conducted under this study.

WRITE Research Program

The WRITE Research Program focuses on research needs, i.e., the generation of information to allow the future demonstration of emerging new pollution prevention techniques. Projects under this component of the WRITE Program address various technical obstacles to waste reduction and industry specific pollution prevention issues. These research efforts are conducted with industrial firms, universities, other government agencies, technical societies, and industrial trade organizations.

Some of the research projects currently underway through the WRITE Research Program include a study to demonstrate the effectiveness of using coated filter media for improved removal of metal in aqueous waste, followed by metal recovery and filter media reactivation and reuse. Chrome is the targeted metal although this process is applicable to a range of metals and metal mixtures. Selective metal recovery techniques using various coating materials, filter substrates, and pH control are being examined. This process has the potential for significant improvement over existing methods that use coagulation, settling and filtration and produce a large mass of sludge that is difficult to dewater and expensive to dispose of. Another research effort is being initiated to examine the development of a method for recycling newsprint into puplp via a dry-disintegration process that maintains fiber

quality and reduces (or eliminates) the major component of waste, i.e., wastewater. The objectives of this research are:

1) Eliminate the requirement for massive amount of water. Besides reducing wastewater this also allows recycling/paper making plant to be located near metropolitan areas that do not have large supplies of cheap water.

2) Enable development of smaller, less expensive machines, sized for the amount of waste paper available. Presently, wet process machinery costs in the $300 to $600 million range and produces hundreds of thousands of tons of newsprint per year.

3) Produce a product equivalent to conventional newsprint using a high percentage of recycled pulp.

4) Conduct studies to identify and prioritize the major pollution prevention research needs in the United States and within select industries.

ASSESSMENT OF FUTURE GOALS

Pollution prevention research is in an area of rapid change. The EPA programs outlined in this paper are at the forefront of the waste minimization effort within the Agency. The goals now include expanding the scope to address waste elimination or reduction in the nonindustrial areas and focus on the effects of product use and used product disposal in addition. Of interest also is the use of product design for thoroughly incorporating pollution prevention considerations. The present system is based on nonconfrontational and cost incentive approaches with industry. Legislation proposed by the

Federal and state governments incorporates mandatory requirements by the public and industry. Passage and implementation of these proposals will have widespread impact on the content of the pollution prevention research program.

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Table I. Summary of engineering evaluation for cold solvent cleaning process modification

Type of Application	Process modification
Stage of Development	Demonstration
Unique Nature of Technology	First-of-a-kind demonstration
Applications	Reduces hazardous waste generation in the cold cleaning operations of the parts cleaning industry, which is a medium/small-scale operation.
Performance	Achieves 50% waste reduction by reducing the fresh solvent requirement by 33%.
Need for Modification	Requires essentially only minor equipment modification.
Cost Effectiveness of Technology	Added capital costs - $600 Net operating savings - $380 per year Payback period - 1.6 years Note: Net operating savings include savings resulting from reduced waste disposal, reduced solvent requirement, and operation and maintenance expense.
Safety & Health	Properly designed system is considered safe. Metal cleaning systems are routinely used in industry without any safety or health problems.